GPS

- The only globally available systems are satellite systems.
- These include:
  - GPS
  - Galileo
  - GLONAS
  - BeiDou

Global Navigation Satellite Systems

- GNSS - Global Navigation Satellite Systems.
- In the 60s - first systems for localization using radio signals transmitted by satellites from Earth's orbit.
- Principle - sufficient amount of radio beacons (in this case satellites of Earth) cover entire Earth's surface by radio navigation signal - it is possible to obtain location anywhere on Earth.
- Advantages - unified coordinate system, operability 24 hours a day.

GPS - Global Positioning System

- Navigation system for localization anywhere on Earth's surface, regardless of weather and measuring time span.
- Originally a military system developed and built from 1973 by Department of Defense of the USA.
- In the 90s, after development and extension it became fully operational in the whole world.
- The Congress of the USA passed a bill to allow use of the GPS in civilian sector.

GPS - Global Positioning System

- Because of the possibility of abuse (terrorist purposes) and securing the primacy of military applications several measures were operated up until 1. 5. 2000:
  - Selected Availability - by design deterioration of positioning accuracy or introduction of the exact P/Y code that distributes the signal only to military applications,
  - Currently, intentional deterioration is already off, which means almost 10 times the increase for civilian users location accuracy.

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GPS - Space Segment

- 24 to 32 satellites (asi of February 2019 there are 27 working and rest as backup), orbital altitude 20,200 km with a circulation time of 11 hours 58 minutes, in six orbits runways.
- Each satellite is equipped with a receiver, transmitter, atomic clocks and instruments for navigation or other special tasks (e.g. for nuclear detonation detection).
- Is equipped with backup power.
- On-board batteries are charged by two solar panels.
- The satellite receives, processes and stores the information transmitted from ground control center for flight path correction thrusters.
- It monitors the status of its own systems and reports information back to the control center.

GPS - Space Segment

- Satellite positioning principle - satellite sends signals to user in the form of a complex signal, each satellite broadcasts its location and approximate location messages of other satellites of the system.
- To determine the current position, the terrestrial receiver computes the so-called pseudo-distances, which is the distances between receiver and visible satellites (above the horizon).

GPS - Space Segment

- The pseudo-distance calculation is based on the knowledge of the speed of propagation the satellite signal and the time difference between the transmission and reception of the signal (pseudo-distance there are introduced additional calculations that help to refine the resulting location further).
- To determine two-dimensional position (most often latitude and longitude) it is sufficient to receive a signal from at least three satellites (calculating three pseudo-distances).
- To determine the three-dimensional position (plus height) of at least four satellites. Receiving a smaller number of satellites makes it impossible to calculate a location, a larger number satellites, on the other hand, further refines location.

GPS - Control Segment

- It is responsible for controlling the entire GPS. Monitors functions of satellites and returns the data to satellites.
- It consists of the main control station in Colorado Springs and the other 5 monitoring stations (US military bases); and ground communication stations which cooperate with the main control station.
- The aim of the entire control subsystem is to monitor each functional satellite, tracking and calculating satellite orbits, communications and ensuring the accurate operation of atomic clocks on satellites.
- Satellite defects are resolved promptly (price $50 million per satellite).

GPS - Control Segment

- There are several independent monitoring networks that allow further more accurate positioning, especially for very accurate applications (geodesy, geodynamics), do not participate on the management and operation of the GPS - e.g. International GPS Service.
- Principle - each time the satellites pass over these stations they are their orbit parameters are evaluated and corrections calculated, which are sent back to the satellites and from there to the receiver, where the stored satellite data will be updated.

GPS - User Segment

- Consists of GPS receivers, users, evaluation tools and procedures.

GPS - User Segment

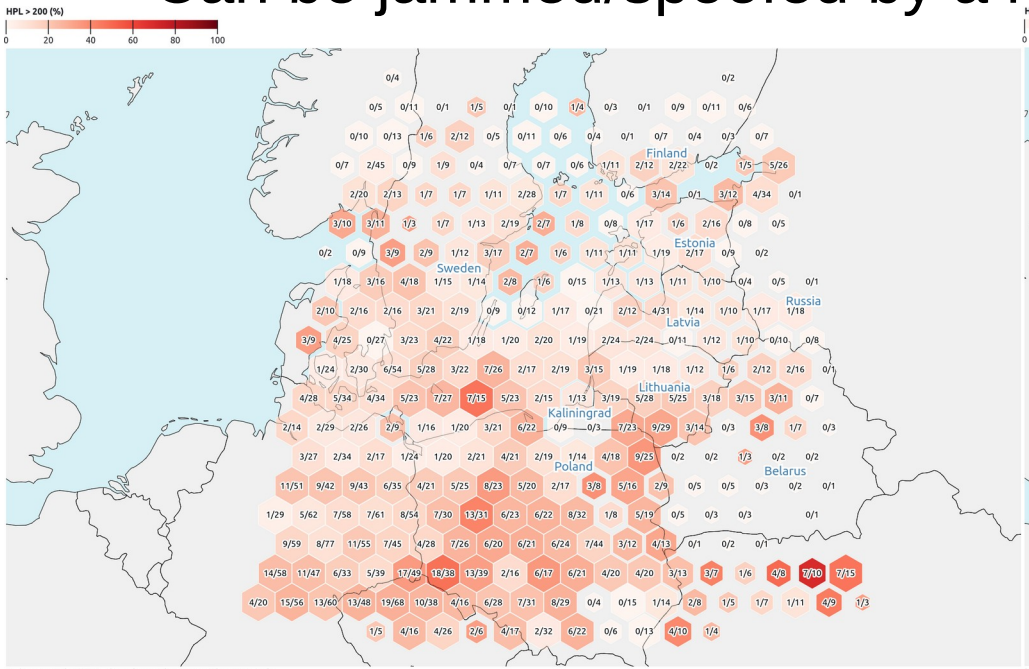
- Ground segment - special receiver with antenna, a radio signal processing unit; and decoding the entered data by the evaluation unit and an output unit for communicating with the operator using the keyboard and display.

GPS

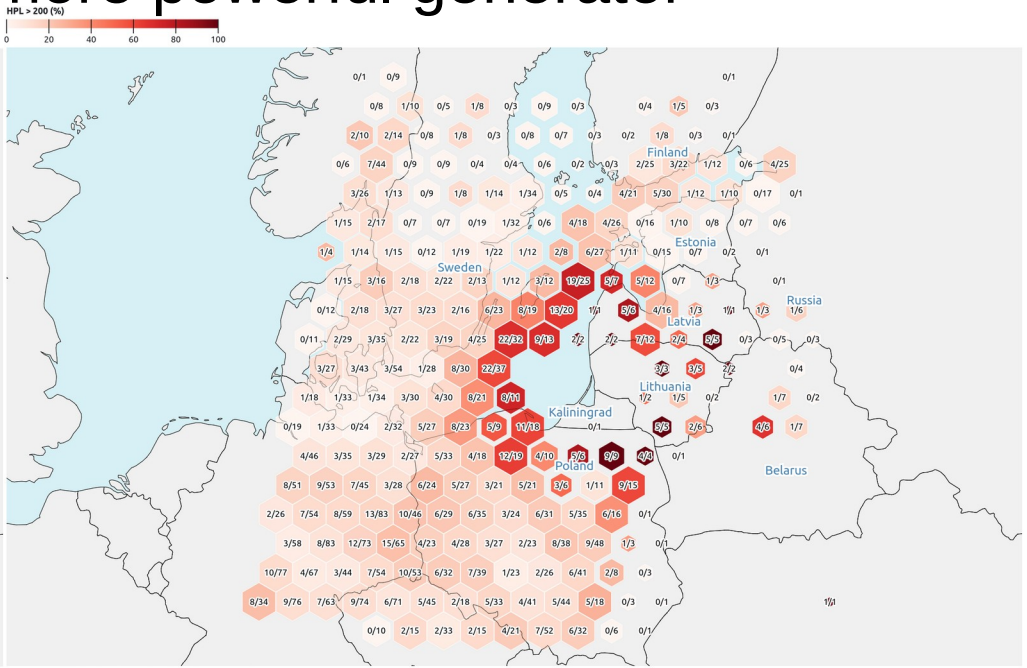
- Application and precision in different areas:
  - civilian - accuracy from 25 m to 100 m, C/A coding (coarse/acquisition code) for rough location,
  - military - accuracy from 2.5m to 15m, code C/A, refinement by a coded signal referred to as P (precision code),
  - DGPS differential GPS (referred to as DGPS), accuracy about 0.5m.

GPS Jamming

- GPS signal is faint
- Can be jammed/spoofed by a more powerful generator



February 5th 2022, data from The OpenSky Network



March 5th 2022, data from The OpenSky Network

[https://observablehq.com/@xoolive/gps-jamming]

GPS Jamming

- Probable deployment of a Krasukha control unit

[https://en.wikipedia.org/wiki/Krasukha_(electronic_warfare_system)]

GPS Jamming

- Previous jamming is probably performed by Krasukha EW system

[https://en.wikipedia.org/wiki/Krasukha_(electronic_warfare_system)]

Galileo

- European Union effort to have its own independent localization service.

Galileo – Space Segment

- Satellites: 22 usable, 2 testing only, 2 unavailable, and 2 retired (as of February 2019).
- 23,222 km orbital height.
- Headquarters established in Prague, Czech Republic.